



artwork: courtesy of Ms. Ellen Dick

Icebergs of Y2k Science Planning Suggestions

This document. This document represents the summary of discussions held at the 2000 WAIS workshop (September, 2000) during a special evening meeting addressing the scientific challenges of iceberg research. The discussion was free-wheeling, and covered many aspects of (a) the scientific rationale for studying the icebergs that recently calved from the Ross and Ronne Ice Shelves and (b) how such studies would be accomplished.

Why study icebergs of Y2K? The first question to address is whether or not the large icebergs (e.g., B15, A43 and A44) should be studied at all. Some of the points cited as reasons why such study would be scientifically valuable:

- **Magnitude.** The icebergs calved in Y2k represent over 4,000 cubic kilometers of fresh water. This is over twice the freshwater released from Antarctica on an annual basis. It represents a loss of ice-shelf area from Antarctica that is over 3 times the total area lost from the Antarctic Peninsula (e.g., Larsen Ice Shelf) since 1960. It is also equivalent to a rainfall of 6 inches over the area of all the Earth's arable land. This water could supply the Los Angeles water district for 50 years.
 - How does the oceanic environment (e.g., salinity stratification) respond to the freshwater released by large calving events such as these? Will such calving events have an impact on ocean circulation around Antarctica?
 - Will flow of the Ross and Ronne Ice Shelves change significantly as a result of the calving events?
 - Are the recent calving events related to climate change?
 - What is the normal frequency of such large calving?
- **A natural "climate change" experiment.** The large icebergs of Y2K will soon drift North where they will encounter warmer atmospheric and oceanic

temperature. Nature is providing an opportunity to observe how a large ice mass will respond to rapid changes in climate conditions. If you can't simulate a climate change in Antarctica, why not follow a piece of Antarctica that goes North to where the environment is warmer?

- It is likely that the 1000's of square kilometer sized icebergs will encounter surface and basal temperature changes equivalent to, or in excess of, the projections for future greenhouse warming in Antarctica. Deployment of devices to monitor surface and basal ablation of these icebergs as they encounter their new, warmer environments would provide data important in testing current empirically based methods for predicting the effects of rapid climate change in Antarctica.
 - Is *slow* climate change, e.g., what is encountered by ice flow across climatic transitions in Greenland (where ablation data is most commonly collected for ice-sheet ablation parameterizations), inherently different from *fast* climate change?
 - What happens when circumpolar deep water (CDW) penetrates sub-ice shelf cavities? One way to find out is to determine how basal melting is enhanced on an iceberg that drifts into warmer waters off the continental shelves.
- **Iceberg calving mechanisms.** The icebergs of Y2k were not unexpected. The large rifts along which the icebergs calved were observed in satellite imagery for up to a decade in advance of actual calving. The importance of rifts to large iceberg calving raises glaciological questions.
 - What are the physical mechanisms of ice-shelf rift propagation, in both the far-field and shelf-front environments?
 - Are extreme events (e.g., storms) required to activate iceberg detachment?
 - Can future iceberg calving events be predicted from observations and models of ice shelves?
 - **Impact on physical environment.** The icebergs calved in Y2k, as seen from satellite imagery, appear to influence sea ice concentration and ocean/atmosphere heat exchange in the Ross and Weddell Seas. It is essential to continue to observe the influence of icebergs on the environment of Antarctica.
 - Do icebergs affect the production rate of high salinity shelf water (HSSW) in the Ross and Weddell Seas?
 - Is the concentration of sea ice enhanced or diminished by the presence of large icebergs?

- Do icebergs regulate melting below ice shelves either directly (through the removal of ice-shelf area) or indirectly (through their influence on water mass production in the surrounding ocean)?
- Where do icebergs loose most of thier mass (and thus freshen surface waters)? Is iceberg melt water a significant control on ocean stratification at sites of deep convection?
- How do icebergs melt? Is break-up an important catalyst for mass wastage of large icebergs?
- What are the controls on iceberg drift? It appears that small icebergs (e.g., B16, which has already drifted beyond Cape Adare) are governed by different dynamics than large icebergs (e.g., B15a which is still near Ross Island).
- How do icebergs influence the seabed?
- How do icebergs carry ice-rafted debris?
- **Impact on biological environment.** As sea gulls often follow ships at sea looking for food in their wake, birds of the Antarctic are often seen following the drift of icebergs (David Vaughan, personal communication). Icebergs may provide a "mass transit system" for the migration of various biological communities from the deep polar region elsewhere.
 - What is the biological productivity in the region surrounding an iceberg? Are changes in productivity from "normal background" levels caused by direct influences of the iceberg or by indirect influences of the iceberg on the oceanic and sea ice environment?
 - Can satellite observations be used to observe the impact of icebergs on sea-surface productivity?
 - Are macrofauna species impacted by the presence of large icebergs?
- **Impact on human social structures.** Some of the icebergs of Y2k may pose a threat to fuel supply shipping for McMurdo station. The logistical and engineering questions required to assess this threat create scientific questions that are still unanswered.
 - Can the drift of a large iceberg be forecast?

What experiments could or should be performed on a large, tabular iceberg?

The second question addressed at the WAIS workshop meeting on icebergs provided a

brainstorming session where various loosely formulated suggestions for research projects were put forward.

- **Biological activities.**

- Obtain continuous records of diatoms in the surface snow stratigraphy and compare with samples of diatoms deposited on the icebergs as they drift north.
- Monitor, using the SeaWiFS satellite, ocean productivity in the wake of iceberg movement.
- Perform deep-sea dives and net casts to determine the activity of marine macrofauna (e.g., whales, seals, fish) in the vicinity of icebergs.
- Determine if icebergs provide refugia for polar communities as they drift North.

- **Geological activities.**

- Determine how iceberg scour marks are introduced into the seabed; determine the geological and oceanographic significance of scour marks left from previous eras of glacial advance.
- Examine the ice-rafted debris deposition by icebergs.

- **Glaciological activities.**

- Determine the controls on ice-shelf rift propagation; examine the events required to release icebergs.
- Determine the mechanical process by which icebergs lose mass from their edges. Monitor iceberg edges.
- Measure iceberg surface ablation and correlate with changing surface meteorological conditions (including surface temperature and surface radiation).
- Measure iceberg basal ablation and correlate with changing oceanic conditions.
- Measure iceberg strain rates and correlate with thickness changes and with sea-ice pressures; use as a means to determine flow-law parameters for simple ice flow conditions
- Measure iceberg internal temperatures as part of the ablation studies.

- Measure the internal temperatures at the margin of an ice-shelf rift to determine rift propagation history.
- Conduct precise GPS, tilt meter, and passive seismic observations at a rift tip to determine how rift tips propagate.
- **Oceanographic activity.**
 - Determine the impact of iceberg melt water on the ocean stratification in the iceberg drift path.
 - Obtain refined observations of tidal amplitudes using icebergs as platforms of opportunity.
 - Model ocean tides in the Antarctic waters to better constrain ice-shelf drift trajectories.
 - Determine how ocean currents are influenced by the presence of large icebergs.
 - Monitor iceberg drift by deploying GPS stations aboard icebergs.
- **Meteorological activity.**
 - Deploy automatic weather stations (AWS) aboard icebergs to determine the relative importance of wind stress as a forcing of iceberg drift.
 - Use ASW data to parameterize surface ablation on icebergs as they encounter warmer climate conditions up North.
 - Determine impact of icebergs on mesoscale weather in the Ross Sea for logistical operations.

How might iceberg research address current goals of the WAIS initiative?

The impact of icebergs on the environment surrounding Antarctica, and of calving on the West Antarctic ice sheet itself, constitute important topics under investigation of the WAIS Initiative. The possible study of icebergs would address the following questions listed in the WAIS science plan:

1. How do rapid global climate changes occur?
2. What is the current configuration of the Antarctic ice sheet?
3. How will the volume of grounded ice change over the next decades to several centuries?

4. What are the physical processes that govern iceberg motion?
5. Do icebergs of large size provide a "social platform" for furthering outreach and education of the WAIS project?
6. What are the connections between the waters of the open ocean and those on the continental shelf?
7. What is the spatial pattern and temporal variability of ocean interaction with the ice shelves of West Antarctica?
8. What will be the spatial and temporal patterns of climatically induced changes in the sea ice and ocean of the Southern Hemisphere?
9. What are the relationships between the northern limit of sea ice or between the leads and polynyas in the sea ice and regional accumulation rates on the ice sheet?
10. What are the modern analogs and experiments which are necessary to establish baselines for interpreting biological phenomena in relation to WAIS dynamics in the past?
11. How have the distribution, abundance and geochemistry of West Antarctic marine and terrestrial species been influenced by ice-sheet marginal phenomena (e.g. ice shelves, ice tongues and piedmont glaciers) since the LGM?